5-12-2015

Exploring Residents' Attitudes toward Solar Photovoltaic System Adoption in China

Yaqin Sun

Exploring Residents' Attitudes Toward Solar Photovoltaic System Adoption in China

Yaqin Sun

Submitted in Partial Completion of the
Requirements for Departmental Honors in Mathematics

Bridgewater State University

May 12, 2015

_____	_____
Dr. Uma Shama, Thesis Director	Date
_____	_____
Dr. Laura Gross, Committee Member	Date
_____	_____
Dr. Xiangrong Liu, Committee Member	Date

Acknowledgement

I would like to thank my thesis mentor Dr. Uma Shama for helping me with my thesis work for the whole year, giving me very useful suggestions and constructive criticism! I also want to thank Dr. Xiangrong Liu for giving me an opportunity to join her group last summer in China to conduct this work. This project is part of a summer ATP group program skillfully led by Dr. Liu in China. She gave me many suggestions and moral support for my future career and success! I also want to thank Dr. Laura Gross who suggested that I take the honors class in Calculus III and first introduced me to the honors program.

I want to thank my parents, Gendi Sun and Hongmei Gui, for encouraging and making it possible for me to come to study in the United States. I also want to thank my landlords, Steve and Margy Elliott, for taking care of me like my parents through my four-year college life!

Thanks to everyone who supported me and helped me when I needed it most!

Table of Contents

ABSTRACT

As the largest energy consuming country, China is facing environmental deterioration, which results from the overuse of non-renewable conventional energy such as coal. Solar photovoltaic (PV) energy, an unlimited and clean energy with minimal impacts on the environment, is considered to be a good alternative to alleviate this severe issue. A survey was designed and conducted among residents in some major cities. Based on the first hand data, basic statistical methods were utilized to examine Chinese residents' knowledge of, concerns, and attitudes towards PV adoption. The research aims to identify the drivers and dynamics that most encourage customers to install solar PV systems in their residential buildings. The significant recommendations from the data include cost reduction, practical government incentives, lowering the percentage of fossil fuel usage, and education to increase awareness of solar PV systems.

INTRODUCTION

China is the largest developing country with the world's largest population of 1.3 billion. The immense economic growth in China has led to an increasing demand for energy. According to (EIA, 2014), the growth of energy demand will still continue to grow. According to Sunpower Corporate Papers (2011), demand is expected to increase by 75 percent by 2035. The conventional energy sources, coal, natural gas, and crude oil which generate 69%, 5%, and 18% of total energy consumption, respectively (Stang, 2014). These conventional energies have brought China some adverse environmental impacts such as air and soil pollution which are hurting public health. According to the data released by the Ministry of Environmental Protection, only 9 of 161 Chinese cities (5%) reach the new air quality standards in the first half of 2014 (Xinhua, 2014). The quality of human life would be threatened without the development of renewable energy sources (Gratzel, 2005). Solar energy, a clean, powerful and safe energy source, is regarded as a good alternative to alleviate this serious environmental problem.

There are many applications for the use of solar energy, such as solar water heating, solar building-heating, solar refrigeration, air conditioners and photovoltaic (PV) systems. China has long utilized solar water heaters, while the solar PV system is a relatively new technology with slow adoption among Chinese citizens. However, the solar water heater is less efficient and convenient than the solar PV system. For example, the solar water heater cannot heat the water during the night due to the lack of sunshine. Also, the solar water heater requires excellent overheating and freezing protection (Haluzan, 2013). In July, because of the high temperature, the solar water heater always over-performed; the panels will heat to around 400 ºF inside. This can accelerate the deterioration of the solar water heating mechanism. Sometimes, it can

directly damage the solar water heating system (Slater, 2013). Solar PV systems can provide most of the heating, cooling, and electricity requirements (Philibert, 2011) and work under most climate conditions. Solar PV systems are more efficient and have more advantages than solar water heaters (Holladay, 2012). Therefore, using the electricity generated locally through PV systems offers greater advantages. In addition, the Chinese government has implemented several policies and incentives to encourage residents to install solar PV system on their rooftops. However, the adoption of solar PV systems is still very slow.

In this research project, surveys were randomly distributed among Chinese citizens in June, 2014 in order to learn about public opinion on the value of Solar PV Systems (SPS). The main goal of this research was to analyze the primary data from the survey, and to assess which factors shaped the Chinese solar PV market, especially in terms of Chinese economic, political and technical development. This thesis aimed to understand

a) Chinese citizens' attitudes toward and interests about installation of solar PV system (SPS), and
b) When and under what circumstances citizens would consider installing SPS.

BACKGROUND

Photovoltaic Effect and Solar Photovoltaic System

Photovoltaic energy converts sunlight into electricity through solar PV (photovoltaic) cells. Sunlight consists of photons, or particles of solar energy. These photons contain various amounts of energy with different wavelengths in the solar spectrum. When photons hit PV cells, they may be reflected, pass through, or be absorbed. Only the absorbed photons provide energy to generate electricity (Bharat Sanchar Nigam Limited, 2011). Today's most common PV device uses a single junction type of cell

to generate electricity (Knier, 2002). This type of PV cell limits the photovoltaic response to the wavelengths of the solar spectrum. PV cells can only absorb the high-energy photons. The current efficiency of this type of PV system (multicrystalline-Si and CIGS modules) is around 15%. By using two or more different cells (monocrystalline-Si modules) with more than one junction, one can reach over 20% efficiency (Tao, 2014). The cells in research laboratories recorded an efficiency in excess of 40% (Cotal, et al., 2009). All these indicate that the efficiency of solar PV cells will increase greatly in the future.

A solar PV system contains multiple photovoltaic modules, casually referred to as solar panels (Muttaqin, 2013). A module consists of small solar cells. A typical single silicon cell produces 1 or 2 watts of power. Generally, one square meter PV module can generate 150 watts of power (Murmson, 2013). The number of solar modules a family needs depends on the region in which they live. According to Mead (2013), people who live in places like Arizona, where average solar insolation per year is around 6 kWh/meters squared/day, will need 53 square meters (574 sq ft) of 15% efficient solar panels. Spending more money for 21% efficient solar panels reduces the required surface areas to 38 square meters (409 sq ft). For the same sized house in Vermont, where the average solar insolation per year is around 4 kWh/meters squared/day, the family will need 80 square meters (861 sq ft) of 15% efficient solar panels and 57 square meters (615 sq ft) of the 21% efficient ones.

One unit of solar module made in China costs $ 810 - $ 891. The cost of the whole solar PV module (about 12 units for a typical family) is around $4,500-$12,000. The power inverter, which converts direct current to alternative current in order to connect to the grid, will cost $1,000-$3,000 (Rudge, 2010). There are other factors that determine the final cost for a solar PV system, such as the size of the system, the

material of rooftop, and wiring. The total cost of installing solar PV system can vary widely within different regions due to different domestic markets, local labor and manufacturing costs, and incentive levels.

Solar Market

China is the largest solar panel manufacturer, and it is soon going to become the largest consumer as well (Internation Trade Adminstration, 2014). The Chinese solar PV panel market has dramatically changed since 2010 (Kaften, 2012). Before 2010, over 90 percent of the Chinese solar panel products were exported overseas (Clark & Cooke, 2014). However, over-exported solar panels significantly hurt the domestic markets of solar panels in other countries because the Chinese solar PV panel industries sold their products in the U.S. below the cost of production. This is the practice known as dumping, which makes the international solar penal market competition unfair. America passed anti-dumping legislation against Chinese solar PV panel manufacturing industries and increased the import duties ranging from 24% to nearly 36% on most solar panels imported from China (Cardwell & Bradsher, 2012). After paying the heavy tariff fee, the price of solar panels made by China was much higher than the local price (EurActiv, 2013). This trade war caused many of the Chinese solar panel companies to go bankrupt with a large amount of the unsold remnants stuck in warehouses, which led to falling revenues and multibillion-dollar deficits. According to the China PV Industry Alliance (Zeng, 2014), Chinese solar panel equipment decreased by 80 percent in just one year in 2012.

Policy

With the great pressure of economic growth, and environmental deterioration, as well as to improve the Chinese solar PV panel market, China pays much attention to solar power development. The Chinese government adopted policies to encourage Chinese

citizens to use solar panels. China's energy policy has set a goal of supplying 15% of energy demand using solar power by 2020 and 27.5% by 2050 (Solangi, Aman, Rahim, Fayaz, & Islam, 2012). In order to meet the target, the Chinese government promulgated a series of laws, policies, and incentives in the last few years (Campbell, 2014). The most significant policies include:

a) The National Development and Reform Commission (Zheng, 2013) stipulating a 20-year subsidy standard for distributed generated PV electricity. Self-generated electricity can get 0.42 yuan ($0.07) subsidy per every kilowatt-hour. Excess electricity would be purchased by local utility companies at a price range between 0.35 and 0.45 yuan/kWh.

b) In some solar rich regions, the price of the power generated by PV station will be lowered to 0.9 yuan or 0.95 yuan/kWh ($0.15) from the previous national standard of 1 yuan/kWh ($0.16) (Zheng, 2013).

c) The National Energy Agency allowed energy generated and distributed by a PV project to receive a 0.9-1.0 yuan/kWh subsidy by selling all power to local grids (McCrone, Usher, Sonntag-O'Brien, Moslener, & Gruning, 2013).

These policies provide significant motivation and drives for the development and use of SPS. The policies of the Chinese government can explain the boost in solar power capacity and increased efficiency. According to the Global Status Report (Sawin, 2013), until 2015 the capacity of solar PV generation increased rapidly from 0.5 Gigawatts (GW) in 2010 to 2.5 GW in 2011, to 7 GW in 2012, and finally arrived at 16.5 GW in 2013.

Barriers

Even with significant Chinese government support, the adoption of solar PV systems in urban areas is limited. One of the possible reasons for the slow adoption could be

that the policy decisions made by the government vary from the adoption decisions made by householders who have different concerns, knowledge and attitudes toward this new technology (Islam & Meade, 2013). The director of Chinese Energy Agency (Wu, 2014), suggested that the biggest barriers that limit the growth in the residential installation of SPS can be classified as

a) Chinese people believe that clean and renewable energy is not needed since conventional energy is cheaper;
b) The technology for solar power production is behind the technology possessed by other global markets;
c) Building structures limit the required space for PV;
d) There is not enough sunshine for solar power production due to weather and pollution;
e) Local governmental policies do not support PV or solar power energy production; and
f) Initial investment costs are too high and the return on investment takes too long.

As the largest population of energy consumers, householders' opinions and attitudes towards SPS adoption would drive the demand and the trend of this market. There is one question in the survey, which asks participants to identify the barriers that would prevent them from adopting solar PV systems, which is based on the barriers Wu listed above.

LITERATURE REVIEW

Current studies indicated that there are two major categories that can determine a family's adoption of solar panel systems: financial incentives and non-financial

reasons. Financial incentives include financial supports provided by central and regional governments. Non-financial reasons include social or peer influences (beiley, et al., 2011), customer's innovativeness (Chen, 2013), and environmental preferences (Bollinger & Gillingham, 2014).

Naveen, Prashant, and Yog (2012) provided empirical evidence that government initiatives and institutional finance can highly affect the adoption of solar PV power supply systems in developing countries like India. Richter (Richter, 2014) concluded that micro-generation technologies are diffused mainly in countries that provide incentives to support installation. Several research projects (Jing & Yugao, 2005, Lester, 2006, Chemi & Kentish, 2007, Rogol, 2007, and Rigter & Vidican, 2010) analyzed the policies' design and implementation, and the influences of these policies and incentives on customers' decisions on the adoption of SPS and SPS market's outlook.

Kaplan (1999) first developed the importance of technical knowledge, motivation, experiences, and familiarity which could significantly influence the interest in PV. Faiers and Neame (2006) explained that environmental concern also has effect on household PV system installation along with the other adoption limitations such as financial, economic and aesthetic characteristics. Islam and Meade (2013) discussed how the lack of information on the new technology slows the adoption of micro-generation technology using renewable energy. Solangi, Aman and Rahim (2012) suggested that the government should improve the application of solar energy, while universities and graduate schools should be encouraged to improve the skill of research in solar energy. Chen (2013) explored the effects of customer innovativeness, environmental value and ecological lifestyles on the adoption of residential solar PV panel systems through survey data. Li, Li, and Wang, (2013) used

surveys to test farmers' purchasing desire by using some factors such as the concern of life quality, the recommendations from close families or neighbors, and government incentives, etc. Richter (2014) explained that the social effects on PV installation in household could be influenced by the nearby local environment.

My research has found only a few papers discussing the adoption of solar energy in China by examining primary data. Hence, this thesis attempted to survey and analyze attitudes of Chinese citizens toward purchasing decisions of residential solar PV systems.

METHODOLOGY

A total of 222 Chinese citizens were involved in the survey, chosen randomly in the streets in the major cities in Shenzhen, Shanghai, Nanchang, Fuzhou, and Beijing. The survey respondents are 50.4% males and 48.1% females. Most of their ages are around 18-26 (64%), and 25% are around 27-40 years old. There are 43.3% of the respondents with the monthly income between $351-$850, and 14.9% of the respondents with monthly incomes below $350, which indicate that most of the participants are in the middle income class. There are 47.6% of the participants with bachelors' degree, and 40.6% beyond undergraduate degree. (Please see Table 1 for the details of demographic information.)

Participants anonymously completed a 12-item questionnaire aimed at understanding the most crucial drives for customers to consider installing solar panels. We sampled participants' opinions on solar panels systems in three major parts:

a) Knowledge and awareness of SPS,

b) Factors driving further development of the SPS market, and

c) Barriers preventing the growth of the SPS Market.

In this research, we used a chi-squared test to compare observed data with data we would expect to obtain according to a specific hypothesis, what scientists call a null hypothesis. In this research, the null hypothesis means that the randomly chosen salary group of participants is independent of factors that could influence the residents' adoption of solar PV systems. The P value determines whether there is a significant difference between the expected data and the observed data from different categories of salary. It helps to find out whether the answers of participants from different salary levels are significantly different. The answers are significantly different in different salary groups when the P value is smaller than 0.05.

Table 1: *Sample demographic Characteristics:*

Gender:		
	Male:	50.4%
	Female:	48.1%
Education:		
	Below Undergraduate degree:	6.5%
	Undergraduate degree:	47.6%
	Beyond Undergraduate degree:	40.6%
Age:		
	18-26	64%
	27-40	25%
	41-60	7%
	Above 60	0.9%
Monthly Income		
	Below $350	14.9%
	$351-$550	21.4%
	$551-$850	21.9%
	$851-$1150	10.2%
	Above $1150	4.2%
	Prefer not to Answer	23.3%

RESULTS

The main purpose of this thesis is to identify Chinese citizens' concerns and attitudes toward purchasing SPS and under what circumstances would households prefer to adopt the solar PV system.

In the survey, we first asked participants to identify which social issues they were most concerned with on a range of 1-5 with 1 being the least concerning and 5 being the

greatest concern (*Appendix I)*. Participants ranked the quality of life and the safety as the top two biggest social issues in China with a score of 3.61 and 3.37. Energy, however, was considered to be the least concerned social issue, which has a score of 2.44. This implies that Chinese citizens do not consider that energy, which could bring pollution, shortage, and climate changes, as the biggest issue in China. However, under the category of energy, people identified that pollution is the biggest issue, which indicated that participants might not be aware of the strong relationship among energy, pollution, safety, and quality of life: clean air would be crucial to life and good health (Pope, Majid, & Dockery, 2009). However, once people realize this link between energy, safety, and the quality of life, the solar panel market would be much more promising. According to Roberts (1996), customers would like to adopt a green product if they have a good knowledge of the green products or the products' contribution to the health of the environment or to the individuals. Meanwhile, the cost of energy is listed as the least important issue, compared with pollution, energy shortage, and waste of energy (see Table 3). This data means the potential of switching from the inexpensive conventional energy to comparatively expensive renewable energy is low; most Chinese citizens appreciate the inexpensive conventional energy. This result is different from the conclusion that one research project suggests. Somasundaram et al. (Somasundaram, Souhib, & Armando,, 2010) explained that the competition with the strong conventional energy industry would not be the major concern for participants to adopt SPS.

The null hypothesis in Table 2 shows that social concerns are independent of the salary groups of the participants. The P value in Table 2 indicates that concerns from the categories of education, pollution from conventional energy, and waste of energy are different when the participants are from different salary groups. The survey

suggested that wealthier people seem more concerned about education and have a higher awareness of sustainability.

Table 2: *Means of the Public Opinion on the Social Issues*

	Employment	Energy	Safety	Quality of Life	Education
Mean	3.01	2.44	3.37	3.61	3.08
P value	0.5398	0.1600	0.3947	0.2678	0.0405*

Table 3: *Means of the Public Opinion on the Energy Issues*

	Pollution from Conventional Energy	Energy Shortage	Cost of Energy	Waste of Energy
Mean	2.80	2.50	2.39	2.40
P value	0.0335*	0.2753	0.2264	0.0014*

In the second part of the survey, we tested participants' awareness of solar power products, their knowledge of government incentives and their attitudes toward SPS markets. According to Table 4, most participants were familiar with solar water heaters and solar batteries since they have used these technologies for a long time. However, few participants used or researched SPS. In Table 5, most people show the intention to continue with or plan to buy solar water heaters and solar batteries within the next five years. Meanwhile, fewer participants showed interest in purchasing SPS within 5 years. This result reflected that awareness and knowledge of solar products influence their participation in the solar product market. It demonstrates that public knowledge of solar production determines its positive intention to buy these products. Also, Foxall et al. (Foxall & Neame, 2006) explained that lack of knowledge will bring uncertainty and confusion to consumers, and therefore, it will decrease the

interests of customers in purchasing. Therefore, it will directly limit the future market growth.

The P value shows that the result of public knowledge of solar batteries, and public purchasing history, and intentions to purchase solar water heaters are different when the participants are from different salary groups. This indicates that people who are wealthy might have their own properties; therefore, they have the right to make a decision to install solar water heater in their own properties.

Table 4: *Public Knowledge of Solar Product (%)*

Product Name	I have used this	I have researched but have not used	I do not know what this is	P value
Solar water heater	75.70	19.15	3.27	0.8770
Solar PV system	4.43	35.04	54.67	0.2440
Solar power Battery	46.72	36.91	14.48	0.0444*

Table 5: *Public Purchasing History and Intention on Solar PV Product (%)*

Product Name	I have purchased this product	I plan to purchase this within 5 years	I do not plan to purchase this within 5 years	I do not know this product	P value
Solar water heater	48.59	25.23	21.02	2.3	0.0235*
Solar PV system	5.60	17.28	39.71	34.11	0.2223
Solar power battery	32.71	22.64	34.11	8.87	0.2202

The participants are asked to note the locations where they observed solar energy products. Participants chose the rooftops of residential buildings, commercial buildings, and the government buildings, with the observation rates of 83%, 36%, and 36% respectively, as the common places that they have seen the solar power productions. According to the result from Tables 4 and 5, we can assume that the

product that people observed most on the roofs of buildings is the solar water heater. The results indicated that in the rural areas of China, there is the capacity for SPS installation because there is enough sunshine and rooftop space. Also, according to Chatila (2014), chief executive officer of US-based producer SunEdison, solar rooftop PV systems in more populated parts of China (Eastern and Southern, where we surveyed) have a promising future compared with isolated areas, because of reduced cost of transmission and distribution.

According to Ansar (2013), consumers are learning about climatic change and environmental issues through the mass media and advertisements. The most common media through which participants have heard or seen news or advertisements about solar PV systems are TV (70%) and the Internet (49%). Indicated by the data, participants believe advertisement on TV (60%) or from utility companies (50.7%) are the most reliable. 77.1% of participants knew that the government has provided some incentives to improve the market of solar PV systems. 66.8% participants hold a positive attitude towards Chinese solar panel market trends. However, 16.8% participants are not certain about the outlook on the future SPS market. 21.9% of people did not know the government support and incentives to encourage the installation of SPS. 7.9% participants did not know the future trend of the market of the solar PV panel.

In the third part of the survey, participants were asked to identify: (a) which barriers would influence the development of SPS markets, (b) which factors would influence their purchasing decisions, and (c) which incentives or policies they prefer government could employ.

In order of importance, the participants listed environmental protection, the awareness of energy saving, government incentives, generating electricity and electricity bill

saving, public opinion, and the recommendations from close friends or relatives as the reasons for them to adopt SPS (see Table 6). Participants considered that the lack of suitable government support and high initial investment cost as two main barriers preventing the growth of the market of SPS (see Table 7). Most of those choices are influenced by the varying needs of people from different salary groups. Participants would prefer that the central government provide a bigger discount on purchasing Solar PV Systems, with a score of 2.07(see Table 8). The results from this section indicated that the cost saving is the major motivation for them to consider the installation of SPS.

The P value shows that three of all participants' preferences on the adoption of SPS are different when they are from different salary groups; these are self-generated electricity to reduce expenses, public opinion, and incentives and programs sponsored by government. This indicates that the preferences could be different according to different salary levels. Different groups bring different needs and concerns to the decision process of purchasing solar panels.

Table 6: *Public Preference on the Adoption of SPS*

Preferences	Average Score	P value
Environmental protection	4.58	0.3156
Self-generated electricity to reduce expenses	3.97	0.0043*
Public opinion	3.69	0.0018*
Incentives and programs sponsored by government	4.19	0.0094*
An increased effort for sustainable energy production	4.26	0.6831
Personal recommendations from family and friends	3.25	0.0538

Table 7: *Public Opinion on the Limitation Preventing the Growth of SPS*

	Yes (%)	No (%)	P value
People's attitude is that clean and renewable energy is not needed and conventional energy is cheaper	16.8	83.1	5.003E-05*
The technology for solar power production is behind the technology possessed by other global markets	38.3	61.6	0.1567
The building structure limits the required space for PV panels and solar power production	29.0	71.0	6.602E-293*
There is not enough sunshine for solar power production due to weather and pollution	25.7	74.2	0.0359*
Local governmental policies do not support PV or solar power energy production	46.2	53.7	0.0355*
Initial investment costs are too high and the return on investment takes too long	40.6	59.3	0.001*

Table 8: *Public Preference on Government Policies*

	Average score	P value
Government offers cash discount on original investment (Purchase of PV panel by consumers).	1.93	0.9421
Government offers discounted electricity rates for system owners with connectivity to the grid.	2.44	0.3778
Government provides low interest loan to assist in initial investment costs.	2.56	0.5175
Restriction on companies' use of conventional fuel sources (e.g. 20% of electricity consumed must be from green sources).	2.96	0.5350

CONCLUSION

Solar PV systems have a brighter future in the domestic market. Chinese citizens are the direct consumer group for the Solar PV Systems; understanding their concerns and preferences could largely improve the market and bring profit. This research focuses on collecting and analyzing Chinese citizens' opinions, concerns, and attitudes on the adoption of SPS. From the survey results, we found out that there are two major barriers of slow adoption of SPS: high initial cost of SPS and lack of knowledge of SPS.

Implications from the research include:

Cost:

a) Giving low interest loans could improve the adoption of SPS. Even with preferable loan policies, solar energy may not be cost competitive with conventional electricity; but these policies could reduce the pressure of the initial investment. If there is not sufficient financial support, SPS will not be a high priority, since most customers only care about the electricity bill (Rundle, Paladino, & Apostoal, 2008).

b) Limiting the electrical output of fossil fuel and increasing the cost of conventional energy can make SPS more competitive with the current strong conventional energy industries.

Consumer education:

a) Increase public awareness of environmental value and ecological lifestyles in order to motivate public to seek and try green products such as SPS.

b) Augment consumer knowledge of solar PV system. According to Rowland et al. (Rowlands & Parker, 2002), customer perception of a renewable electricity source will determine the premium that a green consumer is willing to pay.

c) More trustworthy environmental advertisements in TV and Internet. Akehurst et al. (Akehurst, Afonso, & Goncalves, 2012) explained that environmental advertisements are an effective way to educate consumers with the knowledge about green products and help them make informed decisions. Also, according to Chen et al. (Chen & Chang, 2012), building trust with customers will enhance customers' intentions to buy green products.

Our survey result, based on the chi square test, suggests that government and industry should target different salary groups with specific strategies based on their perceptions as described above.

FUTURE WORK

The above results could help policymakers from the government and industries tp plan and to implement better strategies to encourage more customers to participate in the SPS installation.

Since our samples are mainly residents from the eastern and southern parts of China, a larger sample over the whole country would be better representative of overall public opinion. In addition, the age of most of our participants are from 18 to 40 years. Sampling from different age groups might provide more interesting results. However, as a pilot study in this field, our findings can be potentially extended to research on the adoption of other new technologies.

REFERENCES

Akehurst, G., Afonso, C., & Goncalves, M. (2012). Re-examining Green Purchase Behavior and the Green Consumer Profile: New Evidences. *Management Decision , 50* (5), 972-988.

Ansar, N. (2013). Impact of Green Marketing on Consumer Purchase Intention. *Mediterranean Journal of Social Science , 4* (11), 650-655.

beiley, Z., Hoke, E., Noriega, R., Dacuna, J., Burkhard, G., Bartelt, J., et al. (2011). Morphology-Dependent Trap Formation in High Performance Polymer Bulk. *Advanced Energy Materials , 1* (5), 954-962.

Bharat Sanchar Nigam Limited. (2011, Jan 4). Solar Power. New Delhi, India.

Bollinger, B., & Gillingham, K. (2014). Environmental Preferences and Peer Effects in the Diffusion of Solar Photovoltaic Panels. *Market Science* .

Campbell, R. (2014). *China and the United States—A Comparison of Green Energy Programs and Policies.* Congressional Research Service.

Cardwell, D., & Bradsher, K. (2012, Oct 10). *U.S. Will Place Tariffs on Chinese Solar Panels.* Retrieved 5 11, 2015, from the New York Times: http://www.nytimes.com/2012/10/11/business/global/us-sets-tariffs-on-chinese-solar-panels.html

Chatila, A. (2014). Drive to Install Rooftop Solar Panels on Homes, Factories and Public Buildings. *South China Moring Post.*

Chemi, A., & Kentish, J. (2007). Renewable Energy Policy and Electricity Market Reforms in China. *Energy Policy , 3* (5), 3616-3629.

Chen, K. (2013). Assessing the Effects of Customer Innovativeness, Environmental Value and Ecological Lifestyles on Residential Solar Power Systems Installation Intention. *Energy Policy , 67*, 951-961.

Chen, S., & Chang, C. (2012). Enhancing Green Purchase Intention: the Roles of Green Perceived Risk and Green Trust. *Management Decision , 50* (3), 502-520.

Clark, W., & Cooke, G. (2014). *The Green Industrial Revolution: Energy, Engineering and Economics.* Waltham, MA: Butterworth-Heinemann.

Cotal, H., Fetzer, C., Boisvert, J., King, R., Hebert, P., Yoon, H., et al. (2009). III-V Multijunction Solar Cells for Convertration Photovoltacis. *Energy & Environmental Science* , 174-192.

EurActiv. (2013, Feb 21). *Study claims solar panel tariffs could trigger 242,000 job losses.* Retrieved 05 11, 2015, from EurActiv: http://www.euractiv.com/energy/dubious-study-claims-solar-panel-news-517967

Faiers, A., & Neame, C. (2006). Consumer Attitudes towards Domestic Solar Panel Systems. *Energy Policy, , 34* (14), 1797-1806.

Foxall, A., & Neame, C. (2006). Consumer Attitudes towards Domestic Solar Power Systems. *Energy Policy , 34* (14), 1797-1806.

Gielen, D. (2014). Renewable Energy Prospect: China. *International Renewable Energy Agency* , 15.

Goodstal, G. (2013). Introduction to Alternating Current. In G. Goodstal, *Electrical Theory for Renewable Energy* (p. 72). NY: Cengage Learning.

Gratzel, M. (2005). Solar Energy Conversion by Dye-Sensitized Photovoltaic Cells. *Inorganic Chemistry , 44* (20), 6841–6851.

Haluzan, N. (2013). Solar Water Heating Systems - Advantages and Disadvantages. *Renewable Energy Articles* .

Holladay, M. (2012, Mar 23). *Solar Thermal is Dead.* Retrieved 5 10, 2015, from Green Building Advisor: http://www.greenbuildingadvisor.com/blogs/dept/musings/solar-thermal-dead

Internation Trade Adminstration. (2014). *Renewable Energy Top Markets for U.S. Exports 2014-2015, A Market Assessment Tool for U.S. Exporters.* United States Department of Commerce- Internation Trade Adminstration.

Islam, T., & Meade, N. (2013). The Impact of Attribute Preferences on Adoption Timing: The Case of Photovoltaic (PV) Solar Cells for Household Electricity. *Energy Policy , 55*, 521-530.

Jing, W., & Yugao, X. (2005). Policy Incentives and Grid-connected Photovoltaic System Development in China. *CNOOC Oil Base Group Co. Beijing* .

Kaften, C. (2012). *The 2012 solar year in review and what lies ahead in 2013.* PV Magzine.

Kaplan, A. (1999). From Passive to Active about Solar Electricity: Innovation decision Process and Photovoltaic Interest Generation.

Knier, G. (2002). *How Do Photovoltacis Work.* Retrieved 5 10, 2015, from National Aeronautics and Space Administration: http://science.nasa.gov/science-news/science-at-nasa/2002/solarcells/

Knier, G. (2002). *How do photovoltaics work?* Retrieved August 2, 2014, from NASA Science: http://science.nasa.gov/science-news/science-at-nasa/2002/solarcells/

Lester, R. (2006). China's Energy Policy: Is Anybody Really Calling the Shots? Industrial Performance Center. *MIT-IPC , 6* (2).

Li, X., Li, H., & Wang, X. (2013). Farmers' Willingness to Convert Traditional Houses to Solar Houses in Rural Areas: A Survey of 465 Households in Chongqing China. *Energy Policy , 6* (3), 882-886.

McCrone, A., Usher, E., Sonntag-O'Brien, V., Moslener, U., & Gruning, C. (2013). Global Trends in Renewable Energy Inverstment. Frankfurst: Frankfurt School UNEP Collaorating Center.

Mead, C. (2013). *How Many Solar Panel Do I Need on My House to Become Energy Independent?* School of Engineering. Long Beach: Massachusetts Institute of Technology.

Murmson, S. (2013, Mar 23). *Basic Solar Energy Math.* Retrieved 5 10, 2005, from Solar Power for Ordinary People: https://livingonsolarpower.wordpress.com/2013/03/23/basic-solar-energy-math/

Muttaqin, R. R. (2013, Sep 2). *Photovoltacis System.* Retrieved 5 10, 2015, from Energy Conversion % Photovoltacis System: http://wikaswh.blogspot.com/2013/09/photovoltaic-system.html

Naveen, S., Prashant, K., & Yog, S. (2012). Solar Energy in India: Strategies, Policies, Perspectives and Future Potential. *Renewable and Sustainable Energy Review , 16* (1), 933-941.

Philibert, C. (2011). Solar Energy Perspectives. *Renewable Energy Technologies* , 2.

Pope, A. I., Majid, E., & Dockery, D. (2009). Fine Particle Air Pollution and Life Expectancy in the United States. *360*, 376-386.

Richter, L. (2014). Social Effects in the Diffusion of Solar Photovoltaic Technology in the UK. *EPRG Woring Paper* .

Rigter, J., & Vidican, G. (2010). Cost and Optimal Feed-in Tariff for Small Scale Photovoltaic Systems in China. *Energy Policy* , 6989-7000.

Roberts, A. (1996). Green Consumers in the 1990s: Profile and Implications for Advertising. *ournal of Business Research , 36* (3), 217-231.

Rogol, M. (2007). Why did the Solar Power Sector develop Quickly in Japan? *Massachusetts Institute of Technology of Technology and Policy Program* .

Rowlands, H., & Parker, P. (2002). Consumer Perceptions of Green Power. *The Journal of Consumer Marketing , 19*, 290-130.

Rudge, C. (2010, Aug 6). *Inverters for Solar PV Panels: Your Questions Answered*. Retrieved 5 10, 2015, from YouGen Energy Made Easy: http://www.yougen.co.uk/blog-entry/1516/Inverters+for+solar+PV+panels'3A+your+questions+answered/

Rundle, S., Paladino, G., & Apostoal, S. (2008). Lessons Learned from Renewable Electricity Marketing Attempts: A Case Study. *Business Horizons , 51* (3), 181-190.

Sawin, J. (2013). Renewables 2013 Global Status Report . Renewable Energy Policy Network for the 21st Century.

Slater, H. (2013, Sep 11). *Solar Hot Water: Which Is Better PV or Thermal.* Retrieved 05 10, 2015, from Renewable Energy World: http://www.renewableenergyworld.com/rea/news/article/2013/09/solar-hot-water-which-is-better-pv-or-thermal

Slater, H. (2013, Sep 11). *Solar Hot Water: Which is Better, PV or Thermal?* Retrieved 5 10, 2015, from Renewable Enegy World: http://www.renewableenergyworld.com/rea/news/article/2013/09/solar-hot-water-which-is-better-pv-or-thermal

Solangi, H., Aman, M., Rahim, A., Fayaz, H., & Islam, R. (2012). Present Solar Energy Potential and Strategies in China. *International Journal of Environmental Science and Development , 3* (5), 507-510.

Somasundaram, E., Souhib, H., & Armando,, S. (2010). Current Status and Future Trends in Solar Technology – A Comparative Study of Texas and California. *Department of Electrical and Computer Engineering of the Texas A&M University System* , 689-605.

Stang, G. (2014, Mar). China's Energy Demand : Are They Reshaping the World? *Brief Issue* , 1.

Tao, M. (2014). Status of Solar Photovoltaics. In M. Tao, *Terawatt Solar Phtovoltaics* (p. 12). SpringerBriefs in Applied Science.

Wu, X. (2014). *Insisting on 10 GW Installations in the Distributed Solar PV System.*

Xinhua. (2014, Aug 06). *Only 9 Chinese Cities Reach Air Quality Standards.* Retrieved 05 10, 2015, from Xinhua News : http://news.xinhuanet.com/english/china/2014-08/06/c_133534534.htm

Zeng, K. (2014). Domestic Politics and U.S.-China Trade Disputes over Renewable Energy. *Knowledge-Net for a Better World , 44*, 15.

Zheng, Y. (2013, Aug 31). *China to Subsidize PV Power Units*. Retrieved 05 11, 2015, from China Daily USA: http://usa.chinadaily.com.cn/business/2013-08/31/content_16934093.htm

Appendix I

Survey

Student Customer Survey on Solar PV Power: *This survey is for research purpose only. There is no correct or incorrect answer and you will not be identified for your selected answers or opinion. This version of the survey is intended for college students. Thank you for your time, we appreciate your open and honest answers.*

General Questions regarding opinion on issues

1. Of the following categories where do you feel the greatest issues are? Please rate from 1-5 with 1 being the least concerning and 5 being the greatest concern.

_____ Employment _____ Energy _____ Safety

_____ Quality of Life _____ Education

2. In the category of Energy issues please rank the following concerns from 1-4 where 1 you are least concerned about and 4 you are most concerned about.

____ Pollution from conventional energy sources (Burning oil, gas or coal) ____ Energy Shortages and blackouts (power outages)

____ Waste of energy

____ Cost of energy (electricity/gas)

3. Please indicate your knowledge of the following solar power products

Product Name	I have used this	I have researched but have not used	I do not know what this is
Solar water heater			
Solar photovoltaic system (PV)			
Solar power Battery			
Solar car			
Solar heating system			

Please also write any other solar products and indicate your usage on the line below

_____

4.Please indicate your purchase history and your future purchase desires on solar products

Product Name	I have purchased this product	I plan to purchase this product in the next 5 years	I do not plan to purchase this in the next 5 years	I do not know this product
Solar water heater				
Solar photovoltaic system (PV)				
Solar power battery				
Solar car				
Solar heating system				

Please also write any other solar products and indicate your purchase history & plans below:

_____

5. Please select any locations you have observed PV panels installed

____ Rooftops of residential buildings ____ On ground at solar farms ____Rooftops of commercial buildings (industrial parks) ____ Rooftops of governmental buildings and public buildings ____ Other (please specify:_____)

6. Does the central government offer incentives for investment for PV solar systems ?

A. Yes B. No

7. What is your outlook on the solar pv power market? (Please circle your answer)

A. I am optimistic about it B. I am neither optimistic nor pessimistic about it

C. I am pessimistic about it D. I do not know what the solar pv market will do

8. Where have you seen or heard advertisement for PV systems? (Please circle all that apply)

A1. Television	A2. Radio	B1. Print	B2. Direct mail
B3. Journals	C. Billboard/Street advertisement	D1. Internet	D2. WeChat
D3. Weibo	H. In-store advert	E. Utility companies	F. Friends/family/ colleagues
G. Email		I. Flyers	

9. Which of the following medians do you feel are reliable sources of data? (Please circle all that apply)

A1. Television	A2. Radio	B1. Print	B2. Direct Mail
B3. Journals	C. Billboard/Street Advertisement	D1. Internet	D2. WeChat
D3. Weibo	H. In-store Advert	E. Utility Companies	F. Friends/Family/ colleagues
G. Email		I. Flyers	

10.What action by the government is required to increase consumer participation with self-produced PV solar power? (Please rate the choices in order of 1-4 where 1 would be most influential to increase participation and 4 would be least influential)

____Government offers cash discount on original investment (Purchase of PV panel by consumers)

____ Government offers discounted electricity rates for system owners with connectivity to the grid

____Government provides low interest loan to assist in initial investment costs

____Restriction on companies use of conventional fuel sources (e.g. 20% of electricity consumed must be from green sources)

11. What is limiting the size and growth of the PV industry in China? (Please circle all that apply)

A. People's attitude is that clean and renewable energy is not needed and conventional energy is cheaper

B. The technology for solar power production is behind the technology possessed by other global markets

C. The building structure limits the required space for PV panels and solar power production

D. There is not enough sunshine for solar power production due to weather and pollution.

E. Local governmental policies do not support PV or solar power energy production

F. Initial investment costs are too high and the return on investment takes too long

12. Please indicate your opinions on the following reasons to support a purchase of a PV system

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly disagree
Environmental protection					
Self-generated electricity to reduce expenses					
Public opinion					
Incentives and programs sponsored by government					
An increased effort for sustainable energy production					
Personal recommendations from family and friends					

Demographic questions (please circle your answer)

1. What is your gender? Male Female I prefer not to answer

2.What is your age?(Please circle one)

18-26	27-40	41-60	Older than 60	I prefer not to answer

3. Please indicate your education level:

Below Middle school

Middle school

College Degree

Master Degree

above Master degree

I prefer not to answer

4.What is your monthly electricity bill?

Below 100 yuan

100-300 yuan

300-500 yuan

500-800 yuan

above 800

5. What is your monthly salary range?

Below 1,000 yuan

1,001-3,000 yuan

3,001-5,000 yuan

5,001-8,000 yuan

Above 8,000 yuan

I prefer not to answer

6. What province do you come from? _____